RAe Revision

Capacitor: $Q = VC$

Energy $= \int_0^Q V\,dQ = \int_0^Q \frac{1}{C} Q\,dQ = \frac{1}{C}\frac{1}{2}Q^2 = \frac{1}{2}\frac{V^2C^2}{C^2} = \frac{1}{2}CV^2$.

Inductor: $V = -L\frac{dI}{dt}$. Energy $= \frac{1}{2}LI^2$

Inductive reactance $X_L = 2\pi f L$

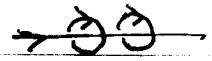
Capacitive " $X_C = \frac{1}{2\pi f C}$

$X = X_L - X_C$ (series), $Z = \sqrt{R^2 + X^2}$

	Series	Parallel	
Inductors	$L = L_1 + L_2$	$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$	(But remember mutual inductance)
Capacitors	$C = \frac{1}{C_1} + \frac{1}{C_2}$	$C = C_1 + C_2$	
Resistors	$R = R_1 + R_2$	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	

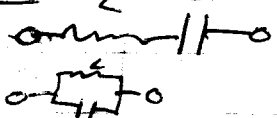
S-rule:

Remember the N pole of a magnet is "north seeking" ie. South.

Corkscrew rule. 

Self inductance $L \propto \frac{\mu_r A T^2}{l}$

Tuned circuits



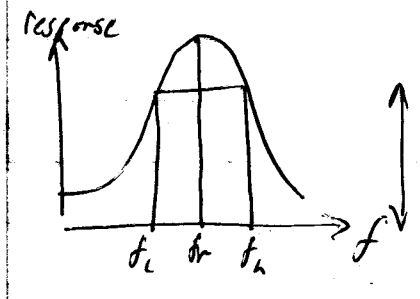
Acceptor — Impedance minimal at resonance.

Rejector — " maximal " "

[use $\frac{1}{X} = \frac{1}{X_1} + \frac{1}{X_2} \ldots$]

Q-factor $Q = \frac{|V_L|}{|V_R|} = \frac{|X_L|}{|R|} = \frac{2\pi f L}{R} = \frac{\omega L}{R}$

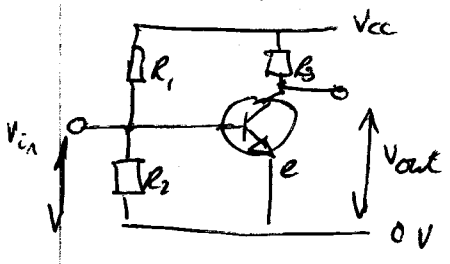
Q determines selectivity.

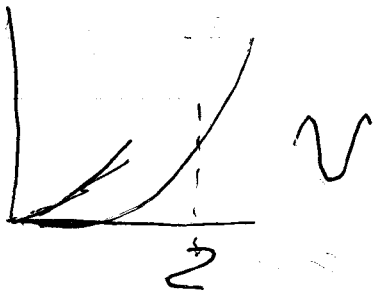


bandwidth $= f_h - f_L$.

$Q = \dfrac{f_r}{f_h - f_L}$.

Class A amplifier. - Common emitter





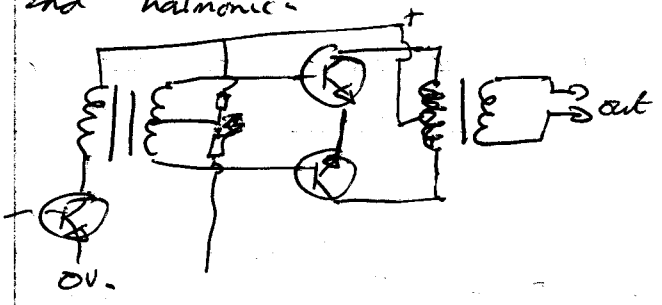
A steady collector current flows.

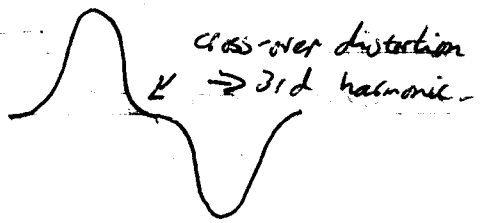
Class B amplifier.

(circuit as above, biased so as to cut off when input -ve).

Highly distorted.

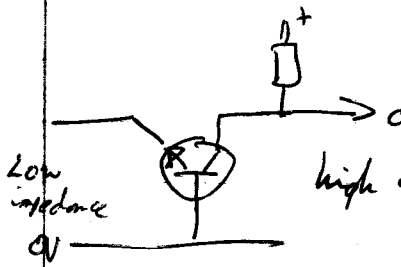
But 2 class B amplifiers in a push-pull circuit virtually eliminate 2nd harmonic.





Class C

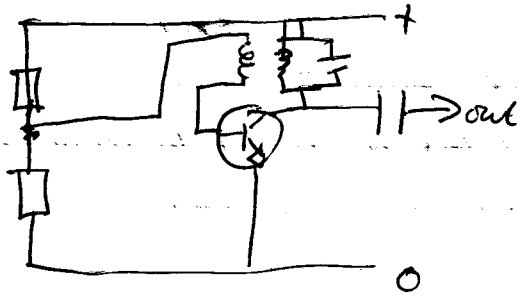
No bias. Highly non-linear need large input. Usually used to drive tuned load



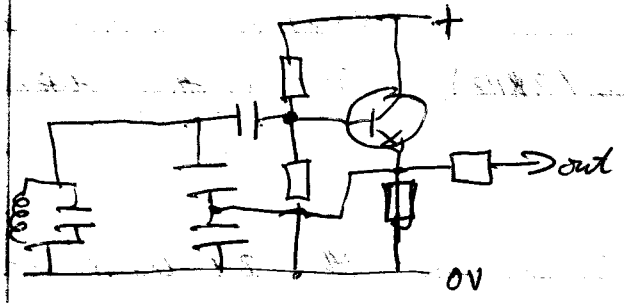
Common - base amplifier.

high impedance.

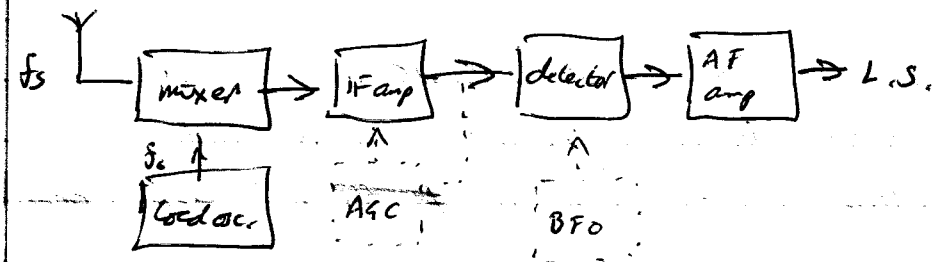
~~Colpitts~~ oscillator.



Colpitts oscillator.



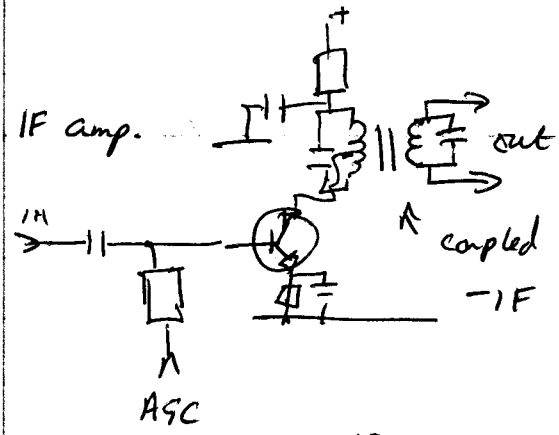
Superhet

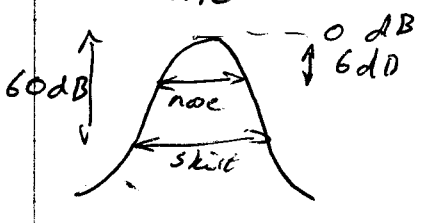


Mixer output = $(f_o - f_s) + (f_s + f_o)$

Generally, $f_o > f_s$ and the $f_o - f_s$ component is selected, as this means that f_o has to be varied over a narrower range

Tracking - the resonance of the LC tuned circuit in the mixer must agree with $f_o - f_s$ over the tuning range. - ~~Calibration~~ fine adjustment of trimming caps etc. needed.





IF amp response

Shape factor = $\frac{\text{skirt}}{\text{noise}}$

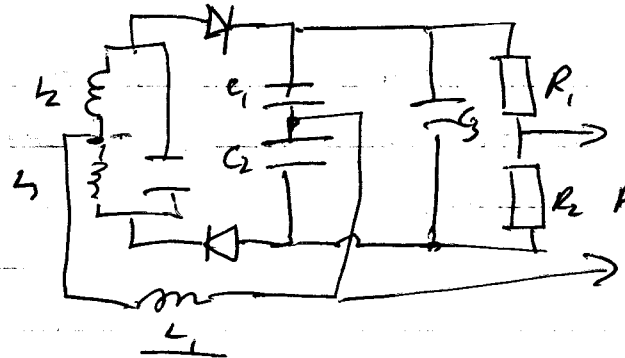
Want this near to 1 (to reduce acceptance of signals at 60dB down).

Can decrease selectivity (⇒ increase bandwidth) by putting a damping resistor across tuned circuit. Useful eg. to switch from telegraphy (0.4kHz) to telephony (3kHz). This is often difficult to do in practice.

For a given Q factor, low IF ⇒ low bandwidth. But low IF means 2nd channel interference more likely. ∴ use <u>double superhet</u>
1st IF 1·6MHz, 2nd 85kHz.

Possible to use IF filters (eg. crystal+LC, mechanical.
Re shape of crystal+LC depends on LC only, so is wide.
Mechanical filters v. good, essential ~~for SSB~~ SSB generation.

For CW, mix IF amp output with BFO.
~~otherwise~~, need detector eg. diode for AM.
FM needs <u>ratio detector</u> (or detune amplitude detector)



$L_2 = L_3$ $C_1 = C_2$ $R_1 = R_2$

C_3 smooth out rapid changes in AF input amplitude.

Foster-Seeley discriminator even better, but sensitive to changes in amplitude — need limiter stages beforehand.

SSB can be detected by re-inserting carrier from BFO, but this requires a large BFO signal (need it small for CW). Instead, use product detector (essentially mix with cio and use filters to select out $f_c - f_c$. Product detectors also good for CW with no change of cio amplitude.

AGC

Problems when receiving CW — switch it out then. (ie. gang it to BFO)

Need quick attack (2ms), slow release (200 ms – 300 ms)

Noise limiter

Diode clipping circuit - takes out large spikes eg. produced by vehicle ignition

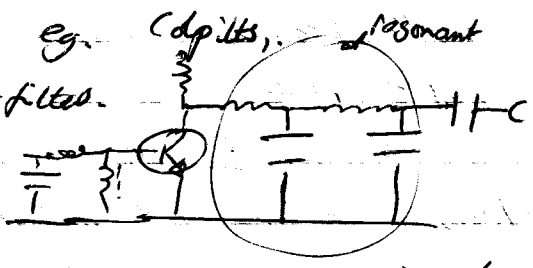
S meter measures agc voltage. 1 S-unit = 4 or 6 dB.

Synchrodyne (direct conversion) mixes down to AF direct.

Tx:

Determine frequency by vfo eg. Colpitts, resonant and multiply up by C-amp + filter.

PA - on low power use L-T

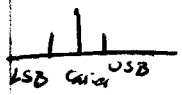


For high-power, need to use transformers, as impedance of transistor may be low.

Modulation

AM

Modulation depth = $\frac{\text{modulation}}{\text{carrier}} < 1$ Must not over modulate.



SSB only Tx one sideband (LSB below 10MHz, USB above)

FM modulating index = $\frac{\text{deviation}}{\text{signal frequency}}$

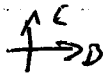
Deviation ratio = max. deviation / max signal frequency

AM Note at 100% modulation, p.e.p. = 4× unmodulated power.

~~Peak~~ mean power = 1.5× unmodulated power.

Advantages of SSB: Bandwidth used = bandwidth of audio ∴ no waste
Considerable effective power gain (4× over AM)
Effected less by disturbances in ionospheric propagation.

Propagation

$\underline{E} \perp \underline{B}$ 

Direction of polarisation is direction of $\underline{E}$.

Ground wave — main mode below 2 MHz. Range a few km at 15–20 MHz.

Ionospheric — 1 → 30 MHz. Refraction + reflection off F2, F1, E Layers.
Ionisation decreases at night. F2 Layer has greatest ionisation + is highest — reflects back at longest distance.
Ionisation depends on time of day + sunspot activity (11 year cycle). Max.
Maximum useable frequency (muf) = highest frequency reflected ~~back~~.
Typically, muf ≤ 25 MHz. Can go up to 50MHz for short periods.
If summer get sporadic E where E Layer reflects up to 100 → 150MHz for hours/days — get strong signals on 28MHz, range 1,500 → 2,500 km.
Critical frequency is highest frequency reflected when sent up vertically < muf
MUF highest in early winter.
Maximum distance F2 reflection can go is 4,000 km — further needs multiple reflection.

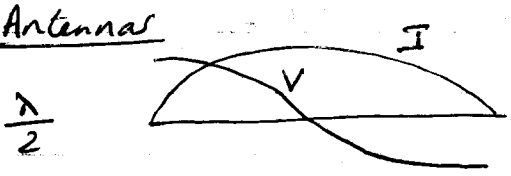
Sudden ionospheric disturbance (s.i.d) or Dellinger fade-out caused by solar flares increasing ionisation of D-layer, which then absorbs TX.

Fade-out of ionospherically propagated signal may also be caused by movement of ~~is~~, change in ionisation, skip distance, destructive interference.

Tropospheric propagation - main mode above 50MHz at long distance. Changes in dielectric constant of troposphere enable waves to be refracted.

Other modes: Troposcatter, meteor ionisation, aurora, moonbounce.

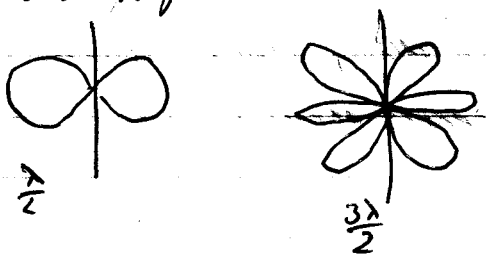
Antennas



Remember 0·95 correction factor.

$\frac{\lambda}{2} = \frac{143}{f(\text{in MHz})}$ ie. 1m at 144MHz.

Radiation pattern:



A.V. long antenna radiates from the ends.

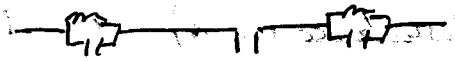
Angle of radiation is angle wrt ground at which max. gain radiated. Depends on antenna height. Must be low for DX, so antenna must be more than $\frac{\lambda}{2}$ off the ground.

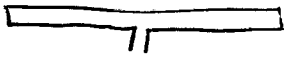
Yagi director | ← | | reflector

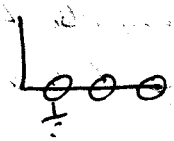
$< \frac{\lambda}{2}$ $\frac{\lambda}{4}$ $> \frac{\lambda}{2}$

forward gain = gain over $\frac{\lambda}{2}$ dipole.

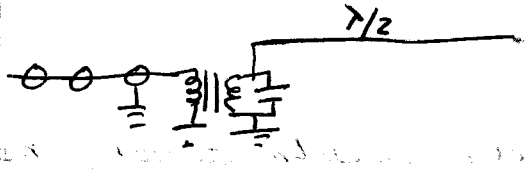
Back-to-front ratio (Brians)

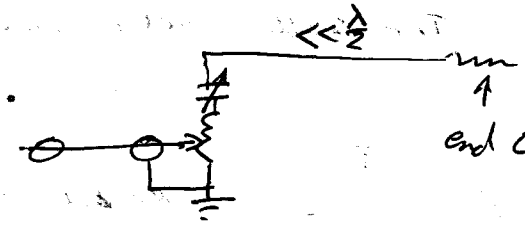
Trap dipole 

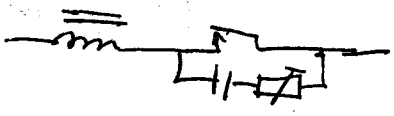
Folded dipole  impedance = cable impedance × 4.

 $\frac{\lambda}{4}$ vertical. Really needs ground plane

End-fed ~~bit~~ random length of wire (best of amateur) ~~is full~~ problems, so use an ATU.





Key-click filter 

Keying too close to VFO → chirp, and following class C stages introduce clicks. However, want to key at a low-power stage.